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TITLE

DEVELOPMENT OF INTEGRATED COASTAL ZONE MANAGEMENT MODEL FOR PARTS OF DAKSHINA KANNADA AND UDUPI DISTRICTS: AN APPROACH BASED ON REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM (GIS)

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INTRODUCTION

Coastal Zones throughout the world have historically been among the most heavily exploited areas because of their rich resources. In coastal countries today an estimated half of the total populations live in coastal zones within the 60km from the coast and migration from inland areas to the coastal is increasing and would rise to almost three quarters by 2020 (Anon,1992). Not surprisingly, there is also a sharp conflict between the need for immediate consumption or use of coastal resources and the need to ensure the long-term supply of those resources (Zeng et al. 1998). In many countries this conflict has already reached a critical stage, with a large part of the coastal zone polluted from local or upland sources, fisheries severely degraded or destroyed, wetlands drained, corals reefs dynamited and beaches long since ruined for human enjoyment. If these coastal resources are to be maintained and restored, effective action is urgently needed. To answer this need a management system has been designed; "*Integrated Coastal Zone Management".*

Integrated Coastal Zone Management (ICZM) is a dynamic, continuous and iterative process designed to promote sustainable management of the coastal zone. ICZM seeks, over the long-term to balance the benefits from economic development and human uses of the coastal zone. The "Integrated" in ICZM refers both to the integration of objectives and to the integration of the multiple instruments needed to meet these objectives. It means integration of all relevant policy areas, sectors, and levels of administration. It means integration of the terrestrial and marine components of the target territory.

The concept of ICZM has been effectively used in most parts of the world (Christie, 2005; Pollnac and Pomeroy, 2005; White et al., 2005) ICZM is an accepted management framework to address coastal and marine environmental problems and conflict and to achieve sustainable use of coastal resources, particularly in developing countries (Barragan Mounoz et

al., 2003; Polanac and Pomeroy, 2005) ICZM encompasses multiple ecological, institutional and socio-economical dimensions (Xue et al., 2004).

The practice of Integrated Coastal Zone Management extends back at least to 1965, in the first decade; the practice was confined to the United States, Australia and UNEP's regional seas program. There was limited expansion of national and sub national ICZM efforts in both developed and developing nations. The mid eighties marked the start of Coastal management literature, particularly conferences proceedings, shows enthusiasm and optimism among those practitioners in the late 60s and early 70s who chose to follow that rising star (Swaminathan et. al., 2005). Now ICZM is practiced all over the globe and is a part of the rhetoric and sustainable development.

At the moment there are 173 sovereign nations that either open on an ocean, sea, gulf, bay, or land locked sea or lake of international significance or both. There are approximately 35 coastal semi sovereign states or overseas states that have been given the legal power by their metropolitan nations to manage their own natural resources and lands-such as creating a Coastal Management Program.

ICZM is a process of management, development of which is carried out at national, regional and local level, involving participation of all the stakeholders and the general public. It is implemented through the establishment of organizational and legal frameworks, instruments and procedures, which are needed for the provision of the optimal combination (Integration) of development plans in the coastal zones, with the aim of protecting natural resources and the environment.

A considerable amount of work has been done on various coastal systems using remote sensing and Geographic information System (GIS) in many parts of the world.

Indian Initiative in Coastal Management:

The then Prime Minister Smt Indira Gandhi in 1981, after taking a note of unplanned development in the coastal areas, wrote a letter to all the coastal states to take adequate measures for protecting the coastal environment.

As the follow-up of the PM's directive, the then Department of Environment and Forest initiated preparation of a guideline for protecting the beaches of the country. These guidelines were prepared by experts and were provided

to the coastal state governments/Union territory administrations for implementation in 1987; however, none of the state/UT governments took the guidelines seriously since it had no statutory backing (Swaminathan et. al., 2005).

The ministry of environment and forest carried out an in-house consultation and issued a draft Coastal Regulation Zone (CRZ) notification, 1989, under Environment (Protection) act, 1986, inviting suggestions and objections from public. Based on the comments received from the public, the ministry finalized the CRZ notification on 19.2.1991. (Gazette of India, 1991) This notification regulates all developmental activities in the CRZ area.

Marine resources management program was initiated as early as 1987, when the Indian Fisheries Act was passed. Several issues related to coastal management were addressed by various ministries and departments of state and central governments. However, all these management initiatives were concentrated on specific issues such as coastal erosion, coastal pollution, ports and harbours, etc. The Coastal Regulation Zone notification issued in 1991 was the first major legislation that was aimed at regulating various coastal activities and protecting the coastal environment. Several institutions have taken up projects and pilot studies in the area of coastal zone Management (Swaminathan et. al., 2005).

In the current situation, the solutions within the individual sector frameworks usually transfer problems to other areas, resources, products or services. Industry and power engineering are able to create a situation wherein the environment becomes unsuitable for any other type of utilization. As problems become more and more critical the transference of coastal problems from one place to another and from one sector to another can be long term.

Today coastal zones require a complex system of management involving an integrated approach. The system must allow for the co-ordination of multiple, often contradictory, interests in order to utilize the resources with a maximum social, economic and ecological benefit for the present and future generations.

Coastal Management issues in Karnataka State:

The coastal zone of Karnataka has been witnessing threat from various anthropogenic activities. Cyclone and floods, though being a matter of concern in other parts of Indian coasts, has not affected the Karnataka coast. Protection of human life, property and natural ecosystems from various hazards is a major concern (Nayak, 2000; Gowda et al., 2004). The major issues associated with the coast of Karnataka are as fallows:

Mangrove ecosystem: it's under stress due to anthropogenic activities such as use of mangrove for fuel, cattle grazing and timber.

Reclamation of land: for activities such as aquaculture, salt pan, and other developmental and recreation purposes.

Coastal process: Shoreline is one of the rapidly changing landform. The accurate demarcation and monitoring of shoreline (short term, seasonal, long-term) are necessary for understanding of coastal process.

Sea erosion: It is the forward movement of the forceful sea waves at the expense of its shore. Swallowing land and property, threatening life and much more. The problems are noticeable in different sensitive spots of the Karnataka coast and become acute during the rainy season when the sea becomes rough. The erosion is clearly visible near Ullal, Kotepur, Maravanthe, Sashihitlu near Mulki (Raghavan, et al, 2001; Kumar & Jayappa, 2009)

Vintage biodiversity: Critical habitats are identified as areas, which are vital to the survival of the species at some phase of the life cycle or to the survival of the community, because of the ecological process, which occur within it. The vintage areas of biodiversity include feeding, nesting, breeding and nursery areas of estuarine and marine organism (Gowda et al., 2004). Many habitats are present all along the coast of the study area. St Mary's Island or Coconut Island of Malpe coast, the estuaries of Sita, Swarna, Udyavara and Netravati River.

It could be observed from the above discussion there is a gap in the knowledge base in the coast of Karnataka especially in the ICZM. Further the surveyed literature invokes the need of ICZM model which would be providing information to the end user. Such a model has been but rarely developed for Coastal Karnataka with precision.

This work here is anticipated to fill the gaps of knowledge in the local scale of coastal Karnataka by providing Coastal Zone Information System for parts of Karnataka Coast.

STUDY AREA

In the coastal belt of Dakshina Kannada and Udupi district (undivided Dakshina Kannada district) it extends over a length of 130 km, lies between Talapadi in the south to Baindur in the north and its adjacent area. It is situated between 75^{o} 00' 00" E 12°45'00"N and 74^{o} 30' 00"E, 13°52'00"N and has been selected for the present study. It is characterized by long, narrow and straight open sandy beaches, spectacular spits, estuaries, barrier beaches, mudflats, and mangroves. Some beaches are important as recreational spots. The beaches are interrupted by a number of natural features and man-made structures. Natural features include estuarine mouths and rock exposures. One major and four minor ports; break waters on either side of the approach channel to the main port, a number of seawall and revetment placed along various beaches account for man-made structures. All these features/structures bring about local irregularity and contribute to erosion/accretion to some extent along the shoreline. There are other parameters responsible for beach morphological and shoreline changes. The sources are beach material, Littoral drift, wave refraction etc.

Southern part of the peninsular India consists of Archaean and Proterozoic rocks and the coastal strips are made up of younger sediments of tertiary to recent age. The area enjoys tropical humid climate, generally the weather is hot and humid throughout the year. The eastern part of the area i.e., the western ghat is cooler than the coastal belt. The climate in the study area is marked by heavy rainfall, high humidity and small variations in temperature. The various climatic parameters like temperature, humidity and evaporation, and rainfall are affecting the land forms of the area. In general the climate of the region may be divided into four seasons (Sadatipour, 1986,; Raghavan, 1988; Bhat, 1992; Udayashankar, 1995).

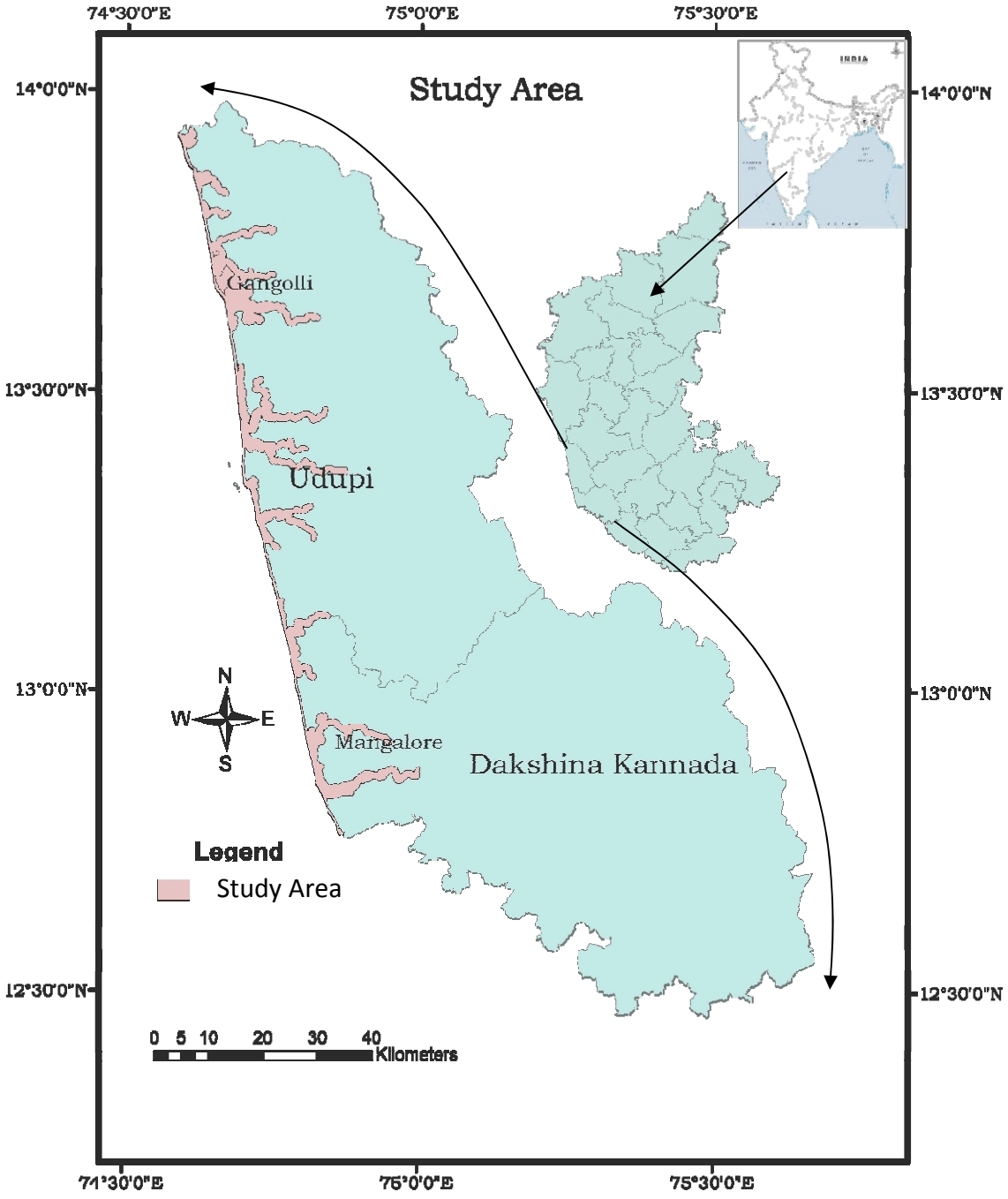

Fig No1: Map of Study area

OBJECTIVES OF THE STUDY

- Generation of different Thematic layers like Coastal land use/land cover, Geology, Slope, Hydrogeomorphology, etc which are in turn used for the Integrated Coastal Zone (ICZM) Model.
- Assessing the Changes in the coastal habitats and change in shore line.
- Development of a Web based graphical user interface, Coastal Zone Management Information System.

METHODOLOGY

The state-of-art Remote Sensing and GIS technology has been used to generate, organize, and interpret the digital database which in turn is used in the ICZM Model.

GIS has proven to be indispensible for Coastal Zone Management (CZM) (Damoiseaux 1995). The role of GIS in CZM has been highly appraised by Ellis(1972), Ader(1982), Fairfield(1987), Davis and Davis (1988), Towened(1990), Welch et al.,(1992), Riddel (1992), Ricketts (1992), Jones (1995), Mumbay et al., (1995), Bartlett (1990, 1994), Deakin and Miment (1994), and Nath et al.,(2000), Thapa and Murayama (2009). The reasons for using GIS in CZM have been well documented by Wright and Barllett (2000) Navalgund et al., (2007). The Spatial Data generated from Remote Sensing data has been analyzed in GIS environment to quantify and also develop the management plan for the coast.

The satellite imagery has immensely helped in mapping of coastal ecosystems and provides estimates of the extent and alteration in land cover in coastal ecosystem. IRS LISS III and PAN Merged data used for macro-level planning and LISS III merged with PAN and LISS IV data has been used for micro level planning (Nayak et al. 1991; Jagtap et al., 2001, Nayak, 2002, Golmehr, 2009; Navalgund, 2006, Navalgund,et al.,2007).

The spatial data is generated from Remote sensing data, SOI maps and other ancillary sources. Most of the spatial data source has been used to project the data on Polyconic Projection (Gupta et al., 2000; Roy et al., 2006).

Generation of Digital database:

Grid coverage/shape file has been generated with the help of tic points collected from the SOI topomap of 1:25,000 scale. The village boundaries from census of India maps/land record or Survey settlement have also been integrated with SOI topographic base maps. The most important aspects of integrated study for the natural resources development is the combined analysis of socio-economic data and natural resources data. The socio economic data is collected by Census Department, Govt. of India and is available village wise. This is mainly the tabular data, however, the thematic data is basically on spatial format, an integrated study requires these two data sets to be combined together to derive meaningful plans for development. All the village boundaries have been digitized and shape files are generated in GIS domain. This map is superimposed on the template created with SOI topographic maps with proper registration. This integration permits in obtaining the spatial information related to natural resources on a village wise basis and also SOI topomap basis. This map has been used to represent the non-spatial data in a spatial format.

Coastal wetland and land use features has been delineated using remote sensing data by hybrid digital interpretation method. Various coastal landuse/land cover features such as agriculture land, forest, estuaries, bays, mangroves, coastal wetlands like, creeks, marshy land, mudflats, beach, sand dunes, barren areas, built-up land, saltpan, the base layers like road, railway and other features are delineated, (Joseph, 2005; Desai et al. 1991; Nayak et al. 1992; Nayak 1996; Nayak, 2002, Thapa and Murayama, 2007, Yogeesh et al., 2004).

The SOI topomaps on 1:25,000 were used as base maps. Each map was in 7.5 X7.5 minutes and follow SOI index system. However the scale of mapping in the study is 1:25,000. However detailed study in Ecological hotspot regions are on 1:5000 scale.

Minimum mapping unit was 2X2 mm, which covers an area as small as 0.25 ha, on 1:25,000. While it is as small as 0.0025 ha on 1:5000 Scale. Ground truth has been carried on selected areas (Shalaby and Tateishi, 2007; Yogeesh et al., 2004). Classification accuracy of maps has been ascertained by randomly selecting points on maps. Each point was visited on ground and accuracy has been estimated using confusion matrix.

The satellite image has been classified to different thematic layers by extracting the features in a digital environment by on screen visual interpretation and also the supervised classification (Leica Geosystems, 2005; Lillesand et al., 2008; Kuemmerle et al. 2006; Lo and Choi, 2004). The different thematic maps are-

Base Map: It contains mainly transport network, settlement locations and administrative boundaries.

Slope Map (Aspect and Altitude): Is one of the important parameters in understanding the land utilization. Slope represents the inclination of the terrain over a distance that is change in elevation over a distance. The slope map is created using the SOI toposheet. The contour information at 20m interval is used for the preparation of slope map. Seven categories of slope were identified and accordingly the maps were prepared (NNRMS 2000).

	Contour Distance	Slope Classes	Percent slope
1	>4 cm	Nearly level	0-1
2	1.33 – 4 cm	Very Gentle	1-3
3	0.88 – 1.33 cm	Gentle slope	3-5
4	0.4 – 0.88cm	Moderate Slope	5-10
5	0.26 – 0.4 cm	Strong slope	10 – 15
6	0.11 – 0.26 cm	Moderately steep	15-35
7	<0.11cm	Very Steep	>35

Table No 1: Seven Categories of Slope

(After National Natural Resource Management System, ISRO Bangalore 2000)

Drainage and watershed Map: For the purpose of planning and development, the first step is the delineation of watershed areas. Micro level delineation is needed for implementation of watershed development activities also useful for planning and avoiding the erosion on coastal areas. Stream network are derived from SOI Topomaps and further updated using satellite images.

Hydrogeomorphology Map: The occurrence, distribution and movement of ground water in hard rock terrain are controlled by a number of factors like lithology, structure, landform thickness of weathered material, soil type etc. The hydrogeomorphological map of the study area has been prepared by visual interpretation of satellite image. Quality check of interpreted layers has been done by field verification. In the field visits the additional hydrological and lithological information were collected on the field. The lithological, structural, geomorphological, hydrological and base map layers were modified based on the field observations. Final quality checks were carried out before integration.

Soil Map: Mapping units contain numerals as symbols to represent map units consisting of soil series/association of soil series information on soil phases given for land management activities. This layer is used as a secondary data.

Shore line change mapping:

Geomorphic process of erosion and deposition and sea level changes continuously modify the shoreline. In addition to the man-made structures such as breakwaters, seawalls and groins may alter nearshore coastal process and the balance of longshore sediment transport, often causing long term shoreline changes. In this context, accurate demarcation of the shoreline is very important for local and regional planning, shoreline change data are critical for coastal managers tasked with establishing setback lines and guiding growth in the coastal zone (Dolan et al., 1991; Crowell et al., 1991). Number of methods have been developed to predict shoreline changes using topographical maps, aerial photos, satellite images, global positioning system etc (Stafford and Langfolder 1971;Dolan et al,1978; Clow and Leatherman 1984;). Synoptic and repetitive converge of the satellite images and high resolution aerial photographs can be successfully used to monitor such long-term shoreline and estuarine morphological changes (Nayak and Sahai, 1985; Raghavan et al., 2001; Bhat, 1995).

The first and most important step is to determine the difference between land and water in the satellite image. That is, define which pixels are land and which are water. After classifying land and water pixels, the raster boundary between land and water can be identified using a filter, thereby delineating the shoreline. In practice, a vector is defined along the land/Water raster boundary, which delineates the vectorised shoreline.

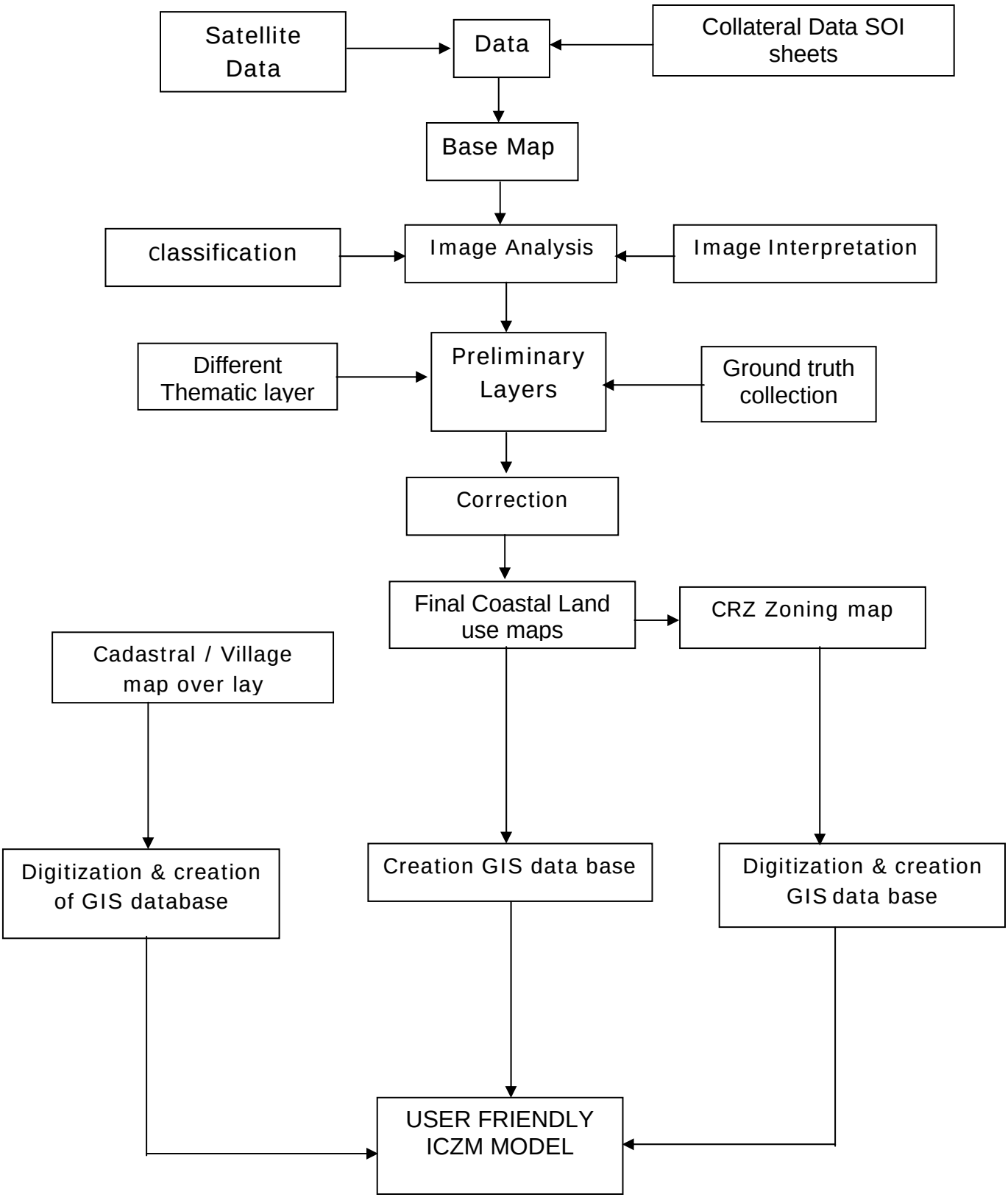

Fig no 2: Methodology flow chart for Database Generation for the ICZM Model.

Spatial image enhancement (Convolution filtering), Spectral enhancement (Principal component, and normalized difference water indices), and spectral classification (maximum likelihood supervised classification). GIS analysis was used to prepare final output maps.

The polygon overlay is a spatial operation that overlays one polygon coverage on another to create a new polygon coverage. The spatial location of each set of polygons. And their polygon attributed is joined to derive new data relationships in the output coverage. Merging of polygons enables to perform the operation to get the new set of polygon combinations. The union and the merging command were mainly used to get the new set of Accretion and Erosion polygons (Gowda et, al., 2005).

COASTAL ZONE MANAGEMENT INFORMATION SYSTEM

Coastal Zone Management Information System (CZMIS) is designed and developed in GIS environment using Microsoft dot net technology to prepare an effective coastal zone management plan for the study area. It is aimed to provide systematic retrieval as well as integration of wide range of data, both spatial and non-spatial for decision making, in addition, to generation of various map outputs. Database design and organization is one of the important tasks prior to creation of database. This is the key factor for any information system to be successful as an efficient management and planning tool. CZMIS has three (Gupta et al 2000) main components (utilization and capabilities).

1. An information Retrieval System
2. Analysis/Modeling tool for coastal zone management plan
3. Map output generation system

As an Information Retrieval System CZMIS can be used to retrieve all the information created in the data base in a user friendly manner. It gives general information like Land use, wetlands, Coastal Regulation Zone boundary, transport boundaries (Administrative and others), and other thematic maps. The sub menus provide composite information about various existing overly layers which can be superimposed on other layers. The user can do query using description/ classification. The map output generation system user can generate its own map for planning and use in the field.

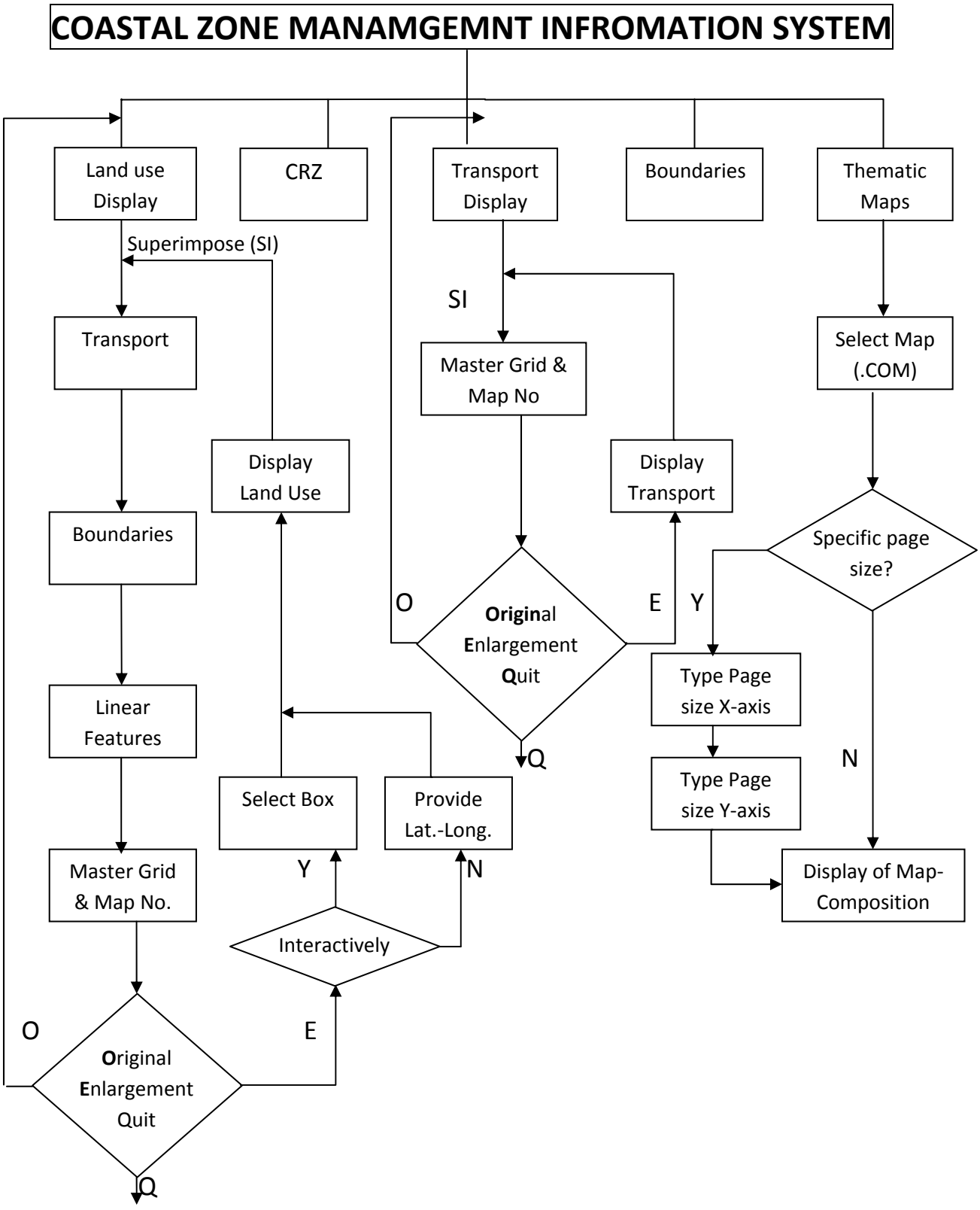

Fig no3: Coastal Zone Management Information System

RESULTS

The total 418.52 Sq km of the study area come under the Coastal Regulation Zone. The major 33% comes under the class habitation with vegetation, followed by agriculture. The category wise area with percent is given in the below table. All this information is utilized in the Coastal Zone Management Information:

Coastal land use/cover category	**Area (Sq km)**	**Per Cent**
Agricultural Land	135.91	32.47
Aquaculture Ponds	3.41	0.81
Beach	0.51	0.12
Creek	1.81	0.43
Forest Man-Made	8.63	2.06
Forest Natural	23.34	5.58
Habitation	3.99	0.95
Habitation with Vegetation	142.08	33.95
Industrial Area	1.30	0.31
Jetty	0.03	0.01
Lagoon	0.07	0.02
Mangroves	2.65	0.63
Marsh Vegetation	0.71	0.17
Mining Area	0.01	0.00
Open/Vacant Land	2.34	0.56
Other Vegetation	0.36	0.09
Ponds	1.08	0.26
Reclaimed Area	0.07	0.02
River	74.91	17.90
Rock Outcrops	1.09	0.26
Salt Pans	0.07	0.02
Sandy Area	6.15	1.47
Tidal Flat/Mud Flat	8.02	1.92
Total	**418.52**	**100.00**

Table No 2: Coastal Land use/Land cover of Study area.

The Individual land use/land cover classes extracted from the study area are explained below:

Agriculture: Occupies 32% of the study area. All along the coast line and adjacent to the rivers/ creeks, the agriculture is dominated.

Forest Natural: Covers just 6% of the study area and covers only 23.33Sq km. This is mainly present in the northern part of the study area. The man-made forest or the forest plantation covers only 2% of the study area, it consists mainly of Casuarina plantation along the coast to prevent the erosion, and also found some cashew plantation on the landward side where the barren land is more prominent.

Tidal flats: The Dakshina Kannada and Udupi coast is straight and wave dominated, thus large patches of mudflats are absent. Small patches of mudflat occur along the estuaries, they are small in size and mangrove and other marshy vegetation is associated with mud flats. It covers only 1.8% of the study area.

Sand/Beach: The coast is straight from NW to SE. It is very indented and marked by numerous river mouths and creeks, small bays, headlands, cliffs, and spits. The bays and inlets associated with pocket beaches are absent from cliff and projected headlands has the width of the beaches in the foreshore i.e. between low tide and high tide and varies from a few meters to about 200m. The backshore beach ranges from 100 to 600m in width (Ahmed, 1972). The sandy area including beach, spit and bars cover just 1.5% of the study area.

Rocky coast: The northern Karnataka coast is more rocky than the southern coast. In our study area the rocky outcrops were found in few places like Someshwara , Suratkal, and Kapu region. Few Rocky islands are present just off Malpe area, the St Mary's island and north and south island just off Udyavara river mouth region.

Mangroves: Are characterized by the presence of particular dominant communities/species, physico-chemical environment, extent and frequency of inundation by tidal waves, salinity and soil types. It is possible to identify major mangrove communities such as Avicennia, Rhizophora and Mangrove scrub using LISS III and PAN data (Nayak et al 1996; Nayak and Bahuguna, 2001, Blasco and Aizpuru, 2002). Mangroves present mainly along the river and majority of them are sparse and fringing type. They are observed at

Babbu Kudru, part of Harikudau, Hangalli near Chakra river estuary. A small patch is found along Kodi hole, some good patches of mangrove are present around Mulki river near Sashi Hitlu, and Pavanje along Pavanje River. A very good patch of Mangrove of Rhizophora and Avicennia sp. are observed at Netravathi estuary. The mangrove is present only 0.6% of the study area, covers only 2.6 sq km.

Habitation: Along the coast, the main habitation area occurs at Mangalore and Kundapur. The industrial area of Mangalore, Baikampadi and Panambur area are present along the Gurpur River. Just 0.93% of the study area comes under Habitation.

Habitation with vegetation: Because of high vegetation density in this region, in most of the places habitation is found with vegetation. In addition to this, paddy and coconut are the main crops in the coastal area. Thus, habitation occurs with vegetation all along the coast just behind the beach, mainly on stabilized dunes. 33% of the study area comes under this class in the CRZ land use classification (Nayak et al 1996).

Reclaimed land: This area of mudflats is converted mainly for agriculture practices. And some areas along the Gurpur and Netravati river tidal flats and marsh areas are reclaimed to industrial practices.

Salt pan: Salt industries are not found in large scale at Dakshina Kannada and Udupi districts, but at very few places near Badakere (48K10SE) we found some saltpans.

Aquaculture pond: This activity is largely concentrated around the Kollur River and Chakra River near to Kattubelturu and east of Kundapur near Kalanjji. At Kundapur, the activity is very near to the mangrove area and can adversely affect the mangroves. 0.7% of the study area belongs to this class.

Slope: It plays a major role in land capability assessment. Slope map represents the inclination of the terrain over a distance. i.e. change in elevation over distance. 40% of the study area comes under 0-1% slope (near level) it is mainly the coastal plain near to the shore area and valley area. 3-5% slope (Gentle slope) almost 16 % of the study area comes under this gentle slope category. This class is mainly found associated with nearly level and very level slope land of the region.

15% of the study area belongs to >35%slope class (very steep slope) This class is mainly present away from the coastal plain and near to the Western Ghats area.

Drainage and watershed: Drainage density is dependent on the factors like relief, rainfall intensity, and infiltration capacity of the soil and vegetation cover. High drainage density is observed towards the eastern part of the area. Entire drainage area of the study area lies in the west flowing river basin.

Geology: The study area consists mainly of Archaean group of rocks. Except for the coastal region, where there are formations to be marked as recent and sub recent deposits and the laterite formations. In the study area five different types of rocks are observed, which belong to respective groups. They are schist, gneiss, charnokite, acidic rocks and granites, up to 70% of the study area is covered by gneisses, which show different ages given by the peninsular gneissic complex rock is dated around 3000-2600 million years pointing to a wide spread influx granitic material. The older metamorphic rocks constitute mainly the Dharwars and they are represented by the banded ferruginous quartzite and to a small extent, by the talc and hornblende schist.

Soil: Coastal plain includes valley, beaches, marshes and backwater areas. Soils of the marshes and back water areas are very deep imperfectly to poorly drained, sandy and clay, alluvial and marine soil. The soils series identified are Kumbashi, Yermal, Mavalli Majaali Bantval, Koni Malpe. These soils have base saturation of 48 to 100 percent and CEC of 1.0 to 4.6 $cmol(+)kg^{-1}$. The organic carbon content is 0.008 to 1.12 % The laterite uplands have moderately shallow to very deep, somewhat excessively drained to well drained, gravelly loam and gravelly clay, laterite soils with abundant iron concentrations and laterite gravels. The uplands are capped with hard iron stone boulders near to the sea coast. The soils identified are mundaje, yadalli, kinnigolli, gondalgudde, kalladi nadabettu, derallakate, jenal.

Shoreline changes

Southern part of Karnataka shows dynamic changes in its shoreline all along the coast but mainly near the river estuaries.

Netravati-Gurpur: Both Netravati and Gurpur rivers are originated in Western ghats and flows westward both the river have common exit to the sea near Mangalore. The two rivers contribute large quantities of sediments to the Arabian Sea during south west monsoon. Annually these rivers deliver highest quantity of freshwater and tons of sediments to the sea every year. The changes noticed at this estuarine mouth are as follows: Ullal barrier spit, which was very small during 1910-1912, has become longer and Bengre spit has been reduced. Width of the Bengre spit at its southern extremity also has undergone reduction very much till 1992. John and Cheryan(1974) also have reported this trend for the period from 1905 to 1968. Continuation of eroding trend of Bengre and a period of stability of Ullal spit between 1974 and 1978 has been revealed by Reddy et al. (1982). Subsequent to the construction of a seawall at the tip of Bengre spit in 1984, the spit has been eroded (Subramanya et al., 1989) to prevent littoral drift entering into the estuary and reduce siltation in the navigational channel of old Mangalore port, breakwaters has been constructed in 1994-95. As a result of this, Bengre spit got stabilized and widened, while the south Ullal spit started eroding and within 2-3 years of time about 100m width of Kotepura beach has been eroded. The maps generated based on multi dated data products and Digital Shoreline Analysis System using the ESRI software also reveal that accretion and erosion sites are getting shifted.

Netravati - Gurpur river (Area in sq meter)				
	Bengre Spit		Ullal Spit	
Year	Accretion	Erosion	Accretion	Erosion
1910-1991	364217.07	161875	121405	242811
1991-2001	121405	20234	28327	101171
2001-2005	161874	80937	8093	141639

Table No 3: Accretion and Erosion at the estuary of the Netravathi Gurpur river.

This has been attributed to shifting of wave convergence zones or due to man-made structures or both. Later during the South west monsoon of 2000, a portion of the southern breakwater and another 100m width of

Kotepura beach got eroded. This has been attributed to convergence of high energetic waves just south of southern breakwater.

Mulki-Pavanje: Mulki and Pavaje rivers originated in the Western ghats. Significant morphological changes are noticed near the mouth of these estuaries. Considerable shift in the river mouth is noticed here over a period of 96 years (1910-2005). Hejmadi Kodi spit, which was very short, has grown by 320m. The former has experienced a loss of land area of 2.5 sq km and the latter has gained about 3 sq km land area due to shifting of the river mouth (Bhat, 1995). Growth of sand bars in the sea near the river mouth during post-monsoon season indicates that the flushing effect of this river is reduced considerably, hence shifting of the river mouth to the north could be due to breaching of Hejamadi Kodi spit by flash floods of Mulki river or due to uplift of landmass along the Mulki-Pullicat lake axis (Subramanya, 1994; Bhatt and Subramanya 2000).

Transact ID	Change (in m sq)	Change in %
100	-41.1630460627	-1.7897
105	30.3791685461	1.3208
106	33.0404936808	1.4365
107	35.6973573097	1.5521
108	38.8673890180	1.6899
109	61.0324313471	2.6536
111	104.1073467666	4.5264
112	-89.8102679765	-3.9048
113	-107.8815167755	-4.6905
114	-98.7725841473	-4.2945
115	-85.6052975817	-3.7220
116	136.1299092508	5.9187
117	-9.8643597767	-0.4289
118	-5.7544203045	-0.2502
119	-21.1080387573	-0.9177
120	-34.6447203508	-1.5063
121	15.2418621433	0.6627
125	4.1166230184	0.1790
126	-75.6425335623	-3.2888
127	-89.1090259815	-3.8743
128	-88.8523183262	-3.8631
129	-114.1445952245	-4.9628
149	-16.6413730405	-0.7235

Table No4: Shore line Change along Mangalore coast

The Negative value shows erosion and the positive value reflects the accretion

Udyavara River: Flows parallel to the sea for a distance of about 10km before joining the Arabian Sea near Malpe, Udupi. This river also originates on the coastal plains and hence is not contributing any significant amount of sediments to the sea. The map is generated using digital Shoreline Analysis System. Break waters have been constructed in 1980s on either side of this river mouth to avoid the siltation of navigational channel of Malpe fishing port. As a result, significant changes (Specially growth of southern spit) are noticed on either side of the breakwaters and this is clearly noticed on the images. The changes in the beach configuration away from this estuarine mouth are influenced by St Mary's group of islands situated in the offshore.

Sita-Swarna River: The river Sita and Swarna originate on the western ghats and flow for a considerable distance in the coastal plain before they form a common estuary near Hangarakatta, about 10km north of Udupi. Estuarine mouth has shifted southwards by ~1.5 km within a span of 57 years (1910-1967). Northern spit has grown towards the estuary by about 2km and southern spit is eroded by 1.5km from the comparison of 1981 topomap and IRS satellite image of 2001. It is found that the northern spit is continued to grow towards the estuary and joins with river islands. Whereas the southern spit has eroded by another ~75m. The width of the northern spit has been considerably increased and there are no changes in the configuration of the southern spit. These changes it can be ascribed that southerly drift is predominating over northerly drift and coastal waves are stronger than river flow in this region.

The river Kollur, Chakra and Haladi are originated in the Western Ghats and flow for a considerable distance before joining the sea they form a common estuary near Kundapur. The estuarine mouth has shifted to the south for a distance of ~500m over the period of about 90 years. During this period the northern spit has grown by 650m towards south and the southern spit has been eroded for about 500m. Gupta (1988) felt that the coastline in this sector is stable except around Gangolli where erosion is a dominant phenomenon.

The multi dated data products study indicates growth and migration of barrier spits and erosion and accretion of beaches which in some areas is adjacent to coastal engineering structures. On the whole, there is predominance of the depositional landforms like the barrier beaches, spits and beach ridges. This clearly demonstrates that the Southern Karnataka

coast is an accretion coast. In additional to the longshore littoral drift, the ongoing unwrap along the Mulki-Pulicat Lake Axis is contributing to continuous modification of the shoreline.

COASTAL ZONE MANAGEMENT INFORMATION SYSTEM

The Graphical User Interface generated as per the ICZM model is web based. The System allows only registered users to use the database. The Centralized Database sits in the server. The user can access the data using internet from any part of the world at any point of time, due to its wide information retrieval capability along with generation of varied information and automatic map outputs. It gives the user to use coastal spatial data, analysis, and query. The few screenshots of the CZMIS are as follows,

Coastal Zone Management Information System - Windows Internet Explorer
http://localhost:1939/ICZIMSystem/Login_Page.aspx
Coastal Zone Management Information System
CZMIS
COSTAL ZONE MANAGEMENT INFORMATION SYSTEM
Welcome to CZMIS
Login
User Id : user1
Password :
Login
Forgot Password : Click Here
Register : Click Here
Not a Member : Click Here
Highlights
Conflicts between human uses and environmental resources in coastal zone are causing negative social perceptions of the human modifications in coastal environments. In contrast to the more optimistic beliefs held in the middle of twentieth century.
Coastal Zones throughout the world have historically been among the most heavily exploited areas because of their rich resources. In coastal countries today an estimated half of the total polulation live in coastal zones, and migration from inland areas to the coast is increasing. Not surprisingly, there is also a sharp conflict between the need for immediate consumption or use of coastal resources and the need to ensure the long-term supply of those resources. In many countries this conflict has already reached a critical stage, with large parts of the coastal zone polluted from local or upland sources, fisheries severely degraded or destroyed, wetlands drained, coral reefs dynamited and beaches long since ruined for human enjoyment. If those coastal resources are to be maintained and restored, effective action is urgently needed. To answer this need, a management system has been designed: Coastal Zone Management Information System (CZMIS)
Read More
Local intranet
100%

Fig No 4: Login Page

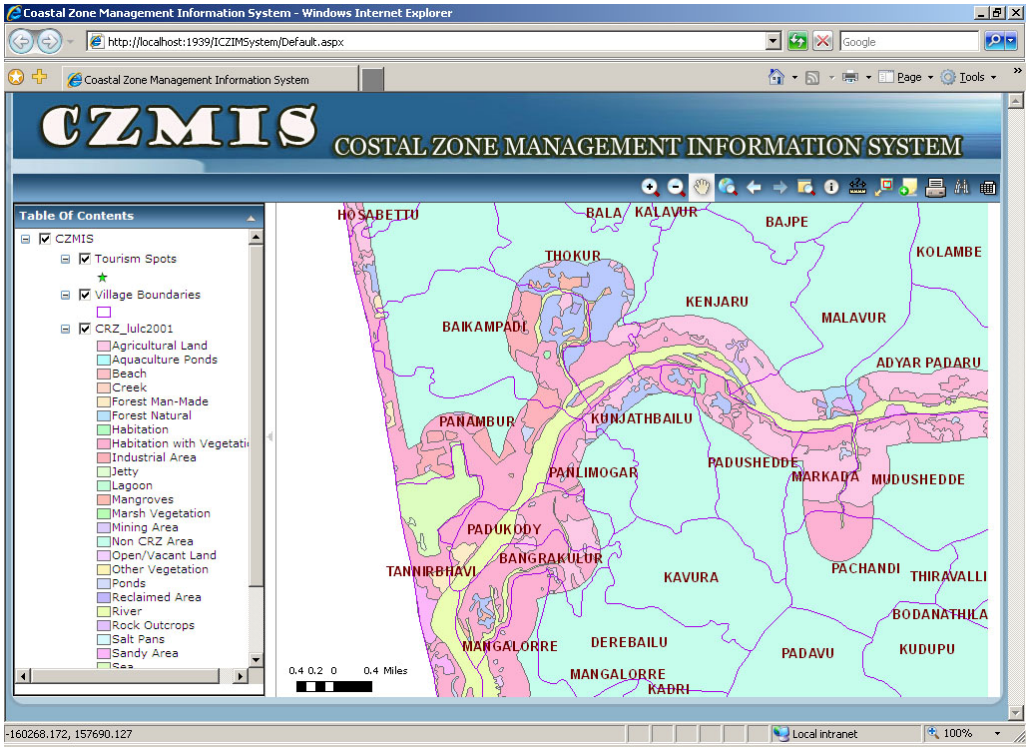

Fig No 5: Landuse landcover map with analysis tools

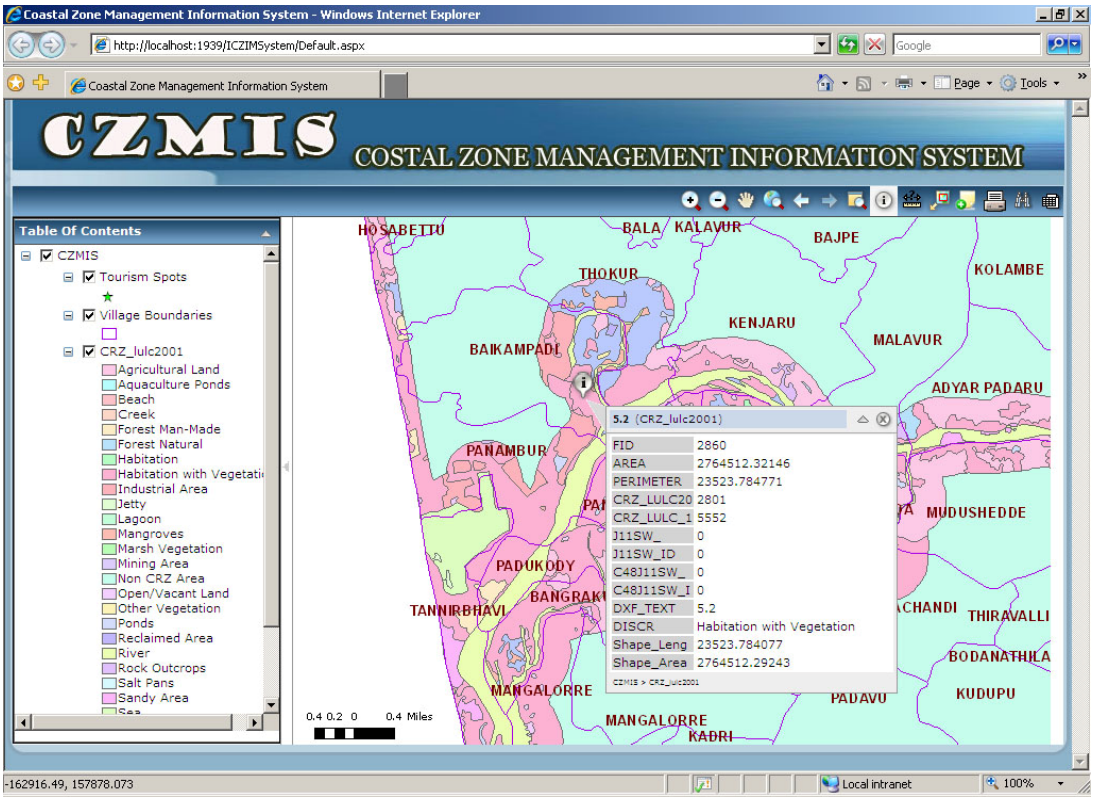

Fig No 6: Landcover map with info tool

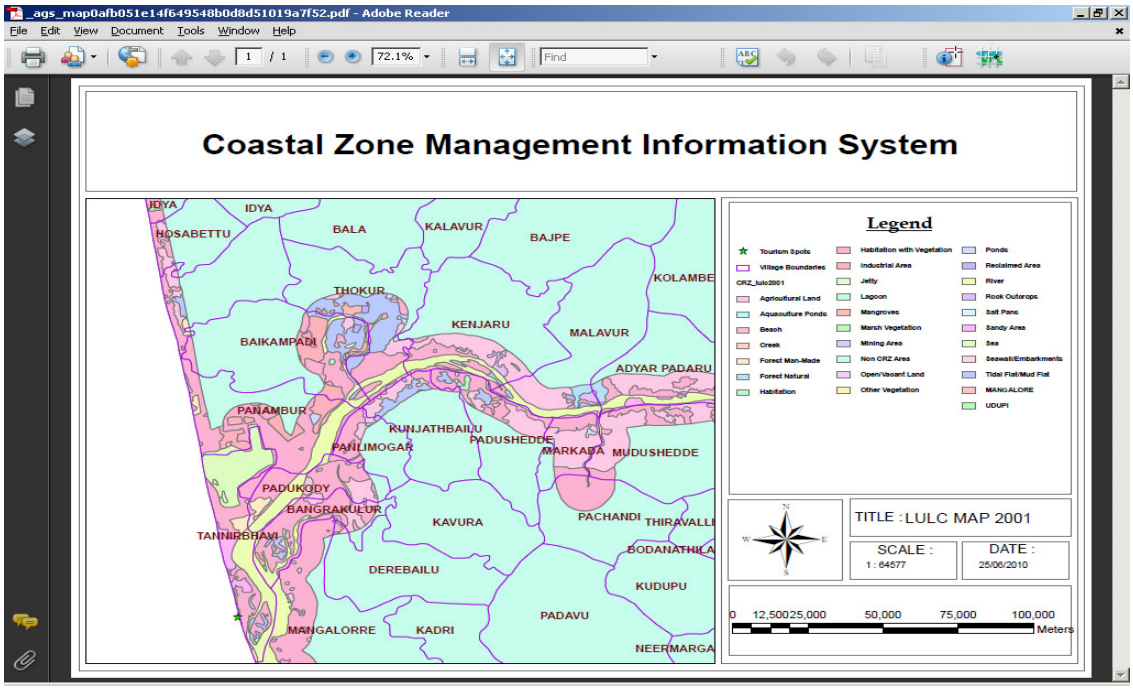

Fig no 7: Map out put generation

CONCLUSION

The Different Thematic maps like, coastal landuse landcover, Geology, Slope, Hydrogeomorphology, Drainage, were prepared. All the themes are generated based on 1:25,000 Scale SOI Topomaps and merge together in GIS environment. In turn this database was used as main resource for the Coastal Zone Management Information System.

The Coastal land use land cover change maps were prepared for the Mangalore and Kundapur region, where the Mangrove habitats are need more attention. The Shoreline changes are assed by different methods. And the change has been quantified. The different year shoreline layers are used along with the other GIS Database in CZMIS.

The Integrated Coastal Zone Management model has been developed, to visualize the different thematic layers of the coastal area and analyses those things CZMIS has been Developed. CZMIS has been tested using a Local server and the web browser.

ICZM programmes will be successful only if coastal communities are involved in these programmes. The state's strategy will need to strike a balance between short and long term social security, livelihood, and hazard risk

reduction needs. In this context, the CRZ Notification 1991 and the M.S. Swaminathan committee report recommends some strategy, Ministry of Environment and Forest (MOEF) issued a new Coastal Management Zone notification. To implement this ICZM is very much important and all stakeholders should participate in the program. The main planners in the national, state and local level can use the CZMIS system to plan their strategies to conserve the coastal area

The economic and environmental situations around the study area are the great problems and possibilities for development. The point is to save natural resources – the basis for the resort welfare for present and future use. This can only be done in sustainable approach and co-operation with all stakeholders. Integrated Coastal Zone Management is considered to be the main instrument which can help to reach sustainable development.

To implement the process of ICZM as soon as possible it is necessary to change the current thinking with respect to spatial planning and strengthen the social participation in the process.

Having a functional zoning plan and the will to enforce it for the long-term perspective, it will be possible to stimulate development and attract the necessary investment for the socio-economic development of the region and make the transition process more stable.

While GIS is not a tool that people found immediately usable, the web based applications provide an interface that is becoming much more familiar and intuitive to users, CZMIS will help the people who are in the field of Coastal Management.

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